Saskatchewan
Agriculture, Food
and Rural
Revitalization

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

19990088

LENTILS FOR THE NEXT CENTURY - DIVERSIFICATION OF RED LENTIL PRODUCTION SYSTEMS IN SASKATCHEWAN

Funded by:
The Agriculture Development Fund

March 2003
Prepared by: University of Saskatchewan

104-00747/

Lentils for the Next Century: Diversification of Red Lentil Production Systems for Saskatchewan

Final Report
March 1, 2003

Project 99000088
Res: 78BW
USASK 7-00317

Investigators
Dr. T. Nleya[1], Dr. Y. Gan[2], Dr. A. Vandenberg[1], Dr. R. Kutcher[3]
Collaborators
Dr. M. Bandara[4], Prof. F. Holm[1], Mr. E. Johnson[5]
[1]Crop Development Centre, University of Saskatchewan
51 Campus Drive, Saskatoon, SK, S7N 5A8

[2]Semi-Arid Prairie Agriculture Research Centre
P.O. Box 1030, Airport Road
Swift Current, Saskatchewan, Canada, S9H 3X2

[3]Agriculture and Agri-Food Canada
Melfort

[4]Crop Diversification Centre-South
SS-4 Brooks Alberta T1R 1E6

[5]Agriculture and Agri-Food Canada
Scott Research Farm

Lentils for the Next Century: Diversification of Red Lentil Production Systems for Saskatchewan

ABSTRACT

The project determined the potential for fall seeding winterhardy lentil in Saskatchewan and assessed the optimum seeding date and optimum N fertilizer rate for early maturing lentil varieties in different crop production zones in the province. Chemical weed control options for early maturing lentil varieties seeded late in spring were also investigated. Emergence in fall-seeded plots was influenced by seeding date, lentil variety and by use of a dormancy enhancer. The final plant density and the seed yield of lentil in fall-seeded plots were approximately 50% of that in spring-seeded plots. Emergence in fall-seeded plots was not consistent from year to year or location to location. This confirms the notion that the performance of fall seeded lentil may be very variable and dependent on weather conditions at the seeding time. The results of the spring seeding date study showed a large decrease in seed yield when seeding was delayed beyond the third week of May at Swift Current, the driest environment. Seed yield was maintained up to the first week of June in the moist Dark Brown soil zone at Saskatoon and up to the second week of June in the moist Black soil zone at Melfort. The N fertilizer experiment showed no difference in yield between the plots that received starter N and unfertilized plots but a delay in maturity of lentil in plots that received high levels of starter N. Single season results from the weed control experiment showed that pre-seeding Roundup burnoff alone will not give adequate weed control even in lentil seeded late in spring. Under high weed pressure the use of Trifluralin followed by Sencor and Poast was superior or equal to pre-seeding Roundup burnoff followed by post-emergence Sencor and Poast.

EXECUTIVE SUMMARY

Lentil production in Saskatchewan is centred in the Dark Brown and moist Dark Brown soil zones. Lentil production is usually not successful in the Northeast part of the province (moist Black or the Grey soil zones) where the soils are often too wet for production of high quality seed or the growing season is too short for the traditional lentil varieties that are late maturing and highly indeterminate. The main thrust of this research project was to develop lentil agronomic packages that could extend lentil production beyond the traditional production areas. The project focussed on red lentil production because this is an expanding segment of the market and thus, the potential market can be fully exploited by expanding the production base.

The first part of the project determined the potential for fall seeding lentil in Saskatchewan. Winterhardy lentil lines from the Mediterranean region and local checks were screened at Saskatoon (Dark Brown soil zone), Swift Current (Brown soil zone) and Melfort (Thin Black soil zone) in Saskatchewan and Brook (Brown soil zone) in Alberta in 1999 and 2000. A dormancy enhancer that prevents water imbibition in the fall to allow the seed to lie dormant till spring was used to coat the seed. Coated seed treatments were compared to uncoated controls. Emergence in fall-seeded plots was influenced by seeding date, lentil variety and by use of a dormancy enhancer. Plant stands in fall seeded plots were extremely poor in both years. While the dormancy enhancer used in this particular study improved overwintering of lentil seed, the final plant stand and seed yield in fall-seeded plots with treated seed were approximately 50% of that in spring-seeded plots.

The second part of the project was aimed at developing agronomic packages for early maturing, determinate lentil varieties developed by the Crop Development Centre and determinate lentil lines from ICARDA. Experiments were conducted to investigate the effect of seeding date, N fertilizer rate and weed control options on the performance of the early maturing lentil varieties. A seeding date experiment was conducted at three locations representing three major soils zones (Brown, Dark Brown and Black soil zones) in Saskatchewan in the summer of 2000 and 2001. The results cautioned against seeding lentil later than the third week of May in dry environments in the Brown soil zone but showed that in moist environments typical of the northeastern part of the province, early maturing lentil varieties may be seeded late with no major penalty in seed yield. The challenge in this part of the province is to come up with effective strategies to manage lentil diseases. The N fertilizer experiment showed no yield response to N fertilizer application. The results of this experiment showed that in years with high rainfall in late summer N fertilizer might delay maturity.

The weed control experiment tested three chemical weed control treatments (pre-seeding Roundup burnoff, pre-seeding Roundup burnoff+post-emergence herbicides (Sencor + Poast) and Trifluralin +Sencor (split) +grass herbicide (Poast) for effectiveness in controlling weeds and enhancing seed yield in two early maturing lentil varieties (CDC Milestone and CDC Redcap). The experiment was conducted at Melfort, Saskatoon and

Scott Research Farm in Saskatchewan. Single season results from the weed control experiment showed that pre-seeding Roundup burnoff alone will not give adequate weed control even in lentil seeded late in spring. Under high weed pressure the use of Trifluralin followed by Sencor and Poast was superior or equal to the pre-seeding Roundup burnoff followed by post-emergence Sencor and Poast.

The results of this study provide important information on suitability of lentil for production in different regions within Saskatchewan. The results will help producers assess crop production risk when making decisions concerning red lentil production.

TECHNICAL REPORT

Background

Lentil production in Saskatchewan is centred in the Dark Brown and moist Dark Brown soil zones. In western Saskatchewan (Brown soil zone) the onset of terminal drought stress, typically in July, occurs during the pod-filling period. A cropping system that would expand the growing season by two to three weeks may stabilise and increase yield by allowing pod-filling period to occur earlier in the growing season. Fall seeding of lentil in under investigation in Mediterranean climates, central Asian highlands and Northwest USA. Fall-seeding winterhardy lentil is potentially more productive if the crop flowers early in spring allowing pod filling to occur earlier in the season before onset of terminal drought stress. Current lentil varieties mature too late to fully take advantage of the pattern of moisture availability in southwestern Saskatchewan

Most lentil varieties from the other parts of the world are poorly adapted to Saskatchewan conditions usually maturing too early and often have very poor yield when grown in the Dark Brown soil zone. The breeding program at the Crop Development Centre has for several years been involved in developing high yielding, early maturing lentil varieties (in comparison to Laird). One of the breeding strategies is to combine the open canopy and extra early maturity of lines from ICARDA with the productivity and adaptation of lines bred in Saskatchewan. These new varieties have improved canopy aeration due to a lower degree of branching. The new lentil varieties offer the potential to shift lentil production in the province northwards to include the Thin Black and Thick Black soil zones, particularly for red lentils for which high yield potential is necessary for Saskatchewan production to be competitive with other suppliers such as Australia, Turkey and USA.

Experiments were conducted to investigate the potential for fall seeding lentil in Saskatchewan and to determine the suitable planting date and the effect of N fertilizer for the early maturing lentil varieties in different parts of the province. Different weed control options were also investigated.

Study 1: Fall-Seeded Lentil

Introduction

Lentil production in Saskatchewan is limited by a short growing season. In western Saskatchewan (Brown soil zone) the onset of terminal drought stress, typically in July, occurs during the pod-filling period. In central (Brown soil zone) and northeastern (Black soil zone) Saskatchewan cool, wet conditions at harvest in September may limit yield potential. A cropping system that would expand the growing season by two to three weeks may stabilise and increase yield by allowing pod-filling period to occur earlier in the growing season.

Fall seeding of lentil is under investigation in Mediterranean climates and Northwest USA. In Syria, autumn-sowing in lentil can result in a yield increase of 100% compared to spring sowing. The yield increase has been attributed to longer vegetative growth periods afforded by early start in spring for fall-seeded lentil. In Turkey, the winterhardiness of lentil germplasm was affected by seeding date and plant density (Kusmenoglu and Aydin 1994). In the USA, winterhardy lentil production is entering the commercialisation phase

Research conducted in western Canada showed that canola seeded late in fall and early in spring flowers and matures earlier and yields significantly higher than canola seeded at the conventional seeding time of mid-May (Johnson et al. 1998). In this system, dry seed is sown just before the soil freezes in the fall and the seed does not germinate until warm temperatures in spring allow germination to proceed. Seed dormancy enhancers that restrict water uptake and permit seeds to lie dormant till warm temperatures have been investigated in canola. Use of the dormancy enhancers permits seeding to be done early widening the seeding date window for producers. Use of dormancy enhancers in canola has produced inconsistent results (Johnson et al. 1998).

In southwestern Saskatchewan, fall seeding winterhardy lentil is potentially more productive if the crop flowers early in spring allowing pod filling to occur earlier in the season before onset of terminal drought stress. In northeast Saskatchewan fall seeding of will prevent delayed seeding due to wet soils. This experiment was designed to investigate the effect of coating lentil seed with dormancy enhancers on survival and establishment of the fall sown lentil crop. The effect of seeding date on overwintering of lentil seed was also investigated.

Materials and Methods

Field studies were conducted in 1999 and 2000 at Saskatoon, Melfort and Swift Current in Saskatchewan and Brooks in Alberta. The soil at Saskatoon was Moist Orthic Dark Brown Chernozemic loam, at Melfort Orthic Black Chernozemic loam, at Swift Current Saskatoon and Brooks Orthic Brown Chernozemic loam. Ten lentil lines, identified from the International Cold Tolerance Nursery (ICARDA) and five local checks, were used in the study (Table 1). Half the seed of each line was coated with dormancy enhancer, obtained from Grow Tec, Alberta, to restrict water imbibition and permit seeds to lie dormant till warm temperatures in spring. The experimental design was a randomized complete block design with treatments arranged in a split plot design. Seeding date was

the main plot and lentil genotype and seed coating treatment were nested within seeding date in a factorial combination. The seeding dates were 3rd week of October and 1st week of November in the fall and one spring seeding date. In 2000, one fall seeding date (1st week of November) possible at Saskatoon due to early freezing of the ground.

The plot size was 0.9 x 3.6 m at Saskatoon, 0.6 x 4 m long at Swift Current and 0.6 x 5 m long at Melfort. The seeding rate was 130 seeds/m^2. No nitrogen fertilizer was applied. Granular inoculant was applied at seeding at all locations. Application of phosphate fertilizer was determined by soil test results for each location. Winter survival was measured by the number of plants in winter seeded plots. Plant count in fall–seeded plots was compared to plant count in spring seeded plots. Seed yield was measured at Melfort and Saskatoon in 2000 fall-seeded plots and 2000 spring seeded plots.

Results

In 1999, emergence in the fall-seeded plots was extremely poor at Melfort and Saskatoon and coating the seed did not improve overwintering or emergence (data not shown). At Swift Current, coating lentil seed with a dormancy enhancer increased plant stand over untreated seed for both fall seeding dates (Table 1). The increase in plant stand due to dormancy enhancer was, however, greater for the November seeding date compared to the October seeding date. Plant stand in the spring-seeded plots was significantly greater compared to both fall-seeded plots. At Brooks, where a subset of the lentil lines were used, the difference in plant stand between the two fall seeding dates was minimal (Table 2). Plant stand in spring seeded plots was more than twice that in fall seeded plots. Coating the lentil seed increased plant stand over the uncoated seeded

In 2000, plant establishment was extremely poor at Swift Current and Brooks (data not shown). At Melfort, coating the seed with dormancy enhancers improved emergence over uncoated treatments (Tables 3). Emergence in the coated treatment was, however, 50% lower than emergence in spring seeded lentil. At Saskatoon, only one fall seeding date was possible in 2000 (Table 3) due to early freezing of the ground. Emergence was very poor in uncoated seed and was improved by coating seed with a dormancy enhancer. Plant stands in coated treatments was however significantly lower than in spring seeded plots.

The seed yield response to seeding date was recorded at Melfort and Saskatoon for 2000 fall-seeded and 2001 spring-seeded lentil. Seed yield in fall-seeded and spring seeded lentil at Melfort is given on Table 5. Coating the seed increased yield significantly over the uncoated control in both fall seeding dates. The seed yield increase due to the dormancy enhancer was higher for the November seeding date than for the October seeding date. At Saskatoon, the dormancy enhancer increased seed yield over the untreated control (Table 6). The seed yield for the treated fall-seeded lentil was, however, 50 % lower than the yield from spring-seeded lentil.

Lentil lines differed significantly in their response to fall seeding and seed coating. Lentil lines that showed a good stand establishment and yield response to fall seeding and to dormancy enhancers across locations include CDC Robin, CDC Redcap, Indianhead, Sazak'91, ILL 1918, SPS ILL 669 and L21. Lentil lines that showed potential for fall

seeding without a dormancy enhancer include Indianhead, CDC Robin, L21 and SPS ILL 669.

Discussion

The results of the study show that fall seeding in lentil results in poor plants stands. While the dormancy enhancer used in this study improved survival of lentil seeds through winter, the plant stand in fall-seeded lentil was still significantly lower than for spring seeded lentil. Delaying seeding till the first week of November gave better results than seeding late in October, likely due to the fact that the ground froze soon after seeding in November. Unfortunately, the advantage of delayed seeding is offset by the unpredictability of weather in Saskatchewan and the possibility of early freezing of the ground. For example, the fall of 1999 was wet and mild whereas the fall of 2000 was dry and cold. In 1999, the wet mild weather in the fall delayed freezing and encouraged water imbibition by lentil seed leading to rotting of lentil seeds and poor plant stand. A dry and cold fall in 2000 resulted in early freezing hence inability to seed in November at Saskatoon. Future research projects should use some of the promising lentil lines identified in this study to screen more dormancy enhancers for performance under fluctuating temperatures. For this technology to work, it is essential to develop dormancy enhancers that will restrict water uptake allowing for early fall seeding . In canola, wide ranges of dormancy enhancers have been evaluated but results have been inconsistent (Johnson et al. 1998). Other important research areas include seeding rates and seeding depth and how these will affect overwintering of lentil seed and hence stand establishment.

Table 1: Plant stand for 1999 fall seeded and 2000 spring seeded lentil at Swift Current, SK

	Seeding date				
	— 3rd week of Oct —		— 1st week of Nov —		Spring
Entry Name	Uncoated	Coated	Uncoated	Coated	Uncoated
	Number of plants /metre row length				
ILL 323	12.2	12.2	17.5	28.7	63.7
ILL 465	16.5	18.8	14.2	42.9	42.9
ILL 468	22.1	19.8	15.5	14.2	53.8
ILL 632	10.9	18.8	39.6	22.1	62.7
L21	9.0	15.5	18.8	24.1	61.7
ILL 1918	12.2	10.9	28.7	30.7	57.1
Sazak'91	20.8	19.8	16.5	35.3	71.6
SPS ILL 669	12.2	47.2	23.1	42.9	45.2
ICARDA check	14.2	47.2	19.8	51.8	49.5
LC 460053	3.3	7.6	12.1	15.5	65.0
Indian head	11.9	16.5	22.1	25.4	32.0
Milestone	18.8	9.9	9.9	23.1	44.5
CDC Robin	3.3	6.6	19.8	30.7	61.7
CDC Sovereign	3.3	3.3	7.6	5.6	59.4
CDC Redcap	2.3	3.3	16.5	26.4	72.6
Mean (seed treatment)	**11.6**	**17.2**	**18.8**	**28.1**	**56.4**
Mean (seeding date)	**14.4**		**23.4**		**56.4**
Sign. (0.05)					
Genotype(G)	*		*		
Seed Treatment (ST)	**		**		
ST x G	*		*		
Seeding date					**

Table 2: Plant stand for 1999 fall seeded and 2000 spring seeded lentil at Brooks, Alta

Entry Name	Seeding date						
	3rd week of Oct			1st week of Nov			Spring
	Uncoated	Coated	Date of 1st Flower	Uncoated	Coated	Date of 1st Flower	Uncoated
	No. of plants/m^2			No. of plants/m^2			No. plants/m^2
ILL 465	29.9	17.6	25 May	12.3	29.4	3 June	52.1
L21	13.9	14.6	27 May	18.5	28.0	30 May	51.2
ILL 1918	14.6	21.3	27 May	4.9	9.7	2 June	56.7
Sazak'91	26.2	25.5	-	13.4	17.4	2 June	55.1
SPS ILL 669	22.5	14.8	3 June	19.4	22.2	31 May	49.8
Indian head	17.8	27.1	4 June	14.4	18.5	28 May	60.9
Milestone	18.8	13.4	3 June	14.4	25.0	-	52.5
CDC Robin	7.6	33.1	3 June	7.6	2.8	-	59.0
CDC Sovereign	9.7	16.7	6 June	14.6	15.5	29 May	60.6
ICARDA check	25.7	29.4	26 May	25.2	32.6	1 June	44.9
Mean	**18.7**	**21.3**		**14.5**	**20.1**		**54.3**

Table 3: Plant stands for the year 2000 fall seeded and 2001 spring seeded lentil at Melfort, SK

	Seeding date				
	— 3rd week of Oct —		— 1st week of Nov —		Spring
Entry Name	Uncoated	Coated	Uncoated	Coated	Uncoated
	Number of plants per square metre				
ILL 323	8	18	3	21	54
ILL 465	11	26	9	31	52
ILL 468	10	22	7	29	57
ILL 632	18	33	20	28	39
L21	25	22	12	36	65
ILL 1918	8	18	12	39	61
Sazak'91	12	35	18	36	65
SPS ILL 669	27	28	40	30	60
ICARDA check	31	17	32	16	51
LC 460053	17	11	3	20	60
Indian head	19	35	36	41	55
Milestone	13	28	19	26	42
CDC Robin	47	37	21	48	64
CDC Sovereign	2	2	0	5	64
CDC Redcap	23	32	51	45	67
Mean (seed treatment)	**18**	**24**	**18**	**30**	**57**
Mean (seeding date)	**21**		**24**		**57**
Sign (0.05)					
Genotype (G)	**		**		
Seed treatment (ST)	**ns**		*		
G x ST	**		**		
Seeding date					**

Table 4: Plant stand for the year 2000 fall seeded and 2001 spring seeded lentil at Saskatoon, SK

	Seeding date			
	3rd week of Oct			Spring
Entry Name	Uncoated	Coated	Date of 1st Flower	Uncoated
	No. of plants/m^2			No. plants/m^2
ILL 323	0	23	June 8	44
ILL 465	2	26	June 10	46
ILL 468	1	12	June 3	48
ILL 632	3	29	June 15	49
L21	0	26	June 6	52
ILL 1918	2	21	June 7	51
Sazak'91	3	23	-	49
SPS ILL 669	2	9	-	50
ICARDA check	6	14	June 12	41
LC 460053	13	17	June 4	50
Indian head	3	21	June 6	43
Milestone	0	12	June 12	54
CDC Robin	2	21	-	55
CDC Sovereign	0	1	-	53
CDC Redcap	0	5	-	60
Mean	**2**	**17**		**50**
Mean (seeding date)	**9.5**			**50**
Sign. (0.05)				
Genotype (G)	*			
Seed treatment (ST)	**			
G x ST	*			
Seeding date				**

Table 5. Seed yield of the 2000 fall-seeded and 2001 spring-seeded lentil lines at Melfort

	Seeding date				
	— 3rd week of Oct —		— 1st week of Nov —		Spring
Entry Name	Uncoated	Coated	Uncoated	Coated	Uncoated
	Seed yield kg ha^{-1}				
ILL 323	0	256	0	478	446
ILL 465	95	264	0	355	420
ILL 468	0	0	0	118	246
ILL 632	269	414	76	501	327
L21	0	89	0	488	405
ILL 1918	0	133	0	145	229
Sazak'91	221	218	0	705	581
SPS ILL 669	359	359	445	382	537
ICARDA check	127	188	357	0	229
LC 460053	0	38	0	189	216
Indian head	615	809	906	829	731
Milestone	0	376	194	362	405
CDC Robin	826	425	335	878	670
CDC Sovereign	0	0	0	0	342
CDC Redcap	481	465	707	604	605
Mean	**200**	**282**	**196**	**402**	**425**
Mean (seeding date)	**241**		**299**		**425**
Sign. (0.05)					
Genotype (G)	**		**		
Seed treatment (ST)	*		**		
G x ST	**		**		
Seeding date					*

Table 6: Seed yield for the 2000 fall seeded and 2001 spring seeded lentil at Saskatoon, SK

	Seeding date		
	1st week of October		Spring
Entry Name	Uncoated	Coated	Uncoated
	Seed yield kg ha^{-1}		
ILL 323	0	457	870
ILL 465	24	509	914
ILL 468	10	246	785
ILL 632	64	468	1029
L21	0	379	693
ILL 1918	0	290	560
Sazak'91	24	449	1121
SPS ILL 669	76	742	1124
ICARDA check	45	125	468
LC 460053	21	644	1196
Indian head	247	921	1695
Milestone	0	398	1141
CDC Robin	30	993	1264
CDC Sovereign	0	55	1414
CDC Redcap	0	183	1251
Mean	**36**	**457**	**1035**
Mean (seeding date)	**247**		**1035**
Sign. (0.05)			
Genotype (G)	**		
Seed treatment (ST)	**		
G x ST	**		
Seeding date			**

Study 2: Late Spring Seeding Of Determinate Mediterranean-Type Lentil

Introduction

Lentil production in Saskatchewan is centred in the Dark Brown and moist Dark Brown soil zones. Lentil production is usually not successful in the northeast part of the province (moist Black or the Grey soil zones) where the soils are often too wet for production of high quality seed or the growing season is too short for the traditional lentil varieties that are late maturing and highly indeterminate. The lush canopy under cool moist conditions also provides an excellent microclimate for development of foliar diseases.

Most lentil varieties from the other parts of the world are too early maturing for Saskatchewan conditions, and often have very poor yield. The breeding program at Crop Development Centre has for several years been involved in developing high yielding, early maturing lentil varieties (in comparison to Laird). One of the breeding strategies is to combine the open canopy and extra early maturity of lines from ICARDA with the productivity and adaptation of lines bred in Saskatchewan. These new varieties have improved canopy aeration due to a lower degree of branching. The new lentil varieties offer the potential to shift lentil production in the province northwards to include the Thin Black and Thick Black soil zones, particularly for red lentils for which high yield potential is necessary for Saskatchewan production to be competitive with other suppliers. A study was conducted with the objective of determining the optimum seeding date and the performance of the early maturing lentil cultivars in three different crop production areas of Saskatchewan.

Materials and Methods

The study was conducted in three different crop production areas in Saskatchewan. The three locations were Swift Current representing the dry environment in the Brown soil zone, Saskatoon representing the Dark Brown soil zone and Melfort representing the moist Black soil zone. Fifteen lentil varieties/genotypes, eight from ICARDA (IC128/85, ILL 7535, ILL 1704, ILL 632, FLIP 92-42L, SLL, FLIP 85-33 and FLIP 95-61L), two from Australia (Digger and Cobber) and five local checks (Milestone, Robin, Redcap, 971-16 and CDC Blaze) were seeded at five seeding dates starting the second week of May and continuing at weekly intervals till the second week of June.

The treatments were arranged in a split-plot design with seeding date as the main plot and lentil varieties as the subplot. Each plot consisted of four rows, 4 m long and 0.30 m apart at Saskatoon and Swift Current and two rows 5 m long and 0.30 m apart at Melfort. No nitrogen fertilizer was applied at Saskatoon or Melfort. Application of phosphate fertilizer was as per soil test results for each location. Granular inoculant was applied at seeding at all locations at a rate of 5.5 $kgha^{-1}$. At Swift Current, Mono-Ammonium Phosphate (11-51-0) was applied at a rate of 33 $kgha^{-1}$ at seeding. Weeds were controlled using herbicides registered for weed control in lentil and by hand weeding when necessary.

Number of days to flowering and number of days to maturity were recorded for each plot. At maturity, each plot was harvested separately using a small plot harvester and seed yield per plot recorded. The seed yield was later converted to $kgha^{-1}$. Data were analyzed

using the General Linear Model procedure of SAS. Data from the two years were not combined due to heterogeneous error variances detected by Barlett's test of homogeneity. Contrast analysis was used to compare lentil genotypes from the CDC breeding program to those from ICARDA and Australia.

Results

In 2000, the location, seeding date, genotype and location x genotype effects for days to maturity were significant. Lentil matured latest at Melfort (90 days to maturity) and earliest at Swift Current (78 days to maturity). The number of days to maturity decreased with delay in seeding (Table 7). The variability for maturity was highest among lentil genotypes from ICARDA. The location, location x seeding date, genotype and location x genotype effects for seed yield were significant. The highest seed yield was recorded at Melfort (1546 kgha^{-1}) and the lowest at Swift Current (907 kg ha^{-1}). The results showed a large decrease in seed yield when seeding was delayed beyond the third week of May at Swift Current, the driest environment (Figure 1). Seed yield was maintained up to the first week of June in the moist Dark Brown soil zone at Saskatoon and up to the second week of June in the moist Black soil zone at Melfort (Figure 1). The genotype and the genotype x location effects for seed yield were significant. Contrast analysis showed that local bred genotypes were superior in yield than ICARDA or Australian genotypes (Figure 2). The location x genotype interaction for seed yield was due to lack of consistence in performance of lentil genotypes across locations.

Table 7. Number of days to flower, number of days to maturity and seed yield of small-seeded early maturing lentil varieties grown at five seeding dates in Saskatchewan for 5 site years

Seeding date	Days to flower	Days to maturity		Seed yield kg ha^{-1}	
	2001	2000	2001	2000	2001
2nd week of May	50	95	91	1434	1056
3rd week of May	47	89	87	1501	1046
4th week of May	46	83	87	1213	1115
1st week of June	40	80	78	1113	1134
2nd week of June	40	75	76	936	936
S.E.	2.5	2.4	1.7	86.6	131.0

Sites: 2000 – Saskatoon, Melfort, Swift Current; 2001 – Saskatoon, Melfort

The summer of 2001 was much drier than 2000 (Appendix 1). The extremely dry weather at Swift Current in 2001 reduced plant growth and seed yield significantly. The Swift Current data from 2001 were excluded from the statistical analysis. The location and location x seeding date effect for number of days to maturity was significant. On average,lentil genotypes matured later (90 days) at Melfort than at Saskatoon (78 days). The location x seeding date interaction was due to the fact that the decrease in days to maturity with delayed seeding was higher at Saskatoon than at Melfort. Lentil genotype differed in days to flowering with genotypes flowering in 42 to 47 days after seeding. Contrast analysis showed that CDC genotypes flowered two days later than ICARDA or Australian genotypes. Lentil genotypes differed in days to maturity. Contrast analysis showed that lentil varieties developed at CDC were earlier maturing (82 days, on average) than ICARDA (84 days, on average) or Australian (85 days, on average) lines. Variability for days to maturity was highest within ICARDA genotypes. Location x seeding date effect for seed yield was significant. Seed yield decrease with delay in seeding was greater at Saskatoon than at Melfort (Figure 1). The genotype and the genotype x location effect for seed yield were significant. Contrast analysis revealed that seed yield for CDC bred lentil genotypes was significantly higher than for ICARDA-bred or Australian- bred lentil genotypes (Figure 2).

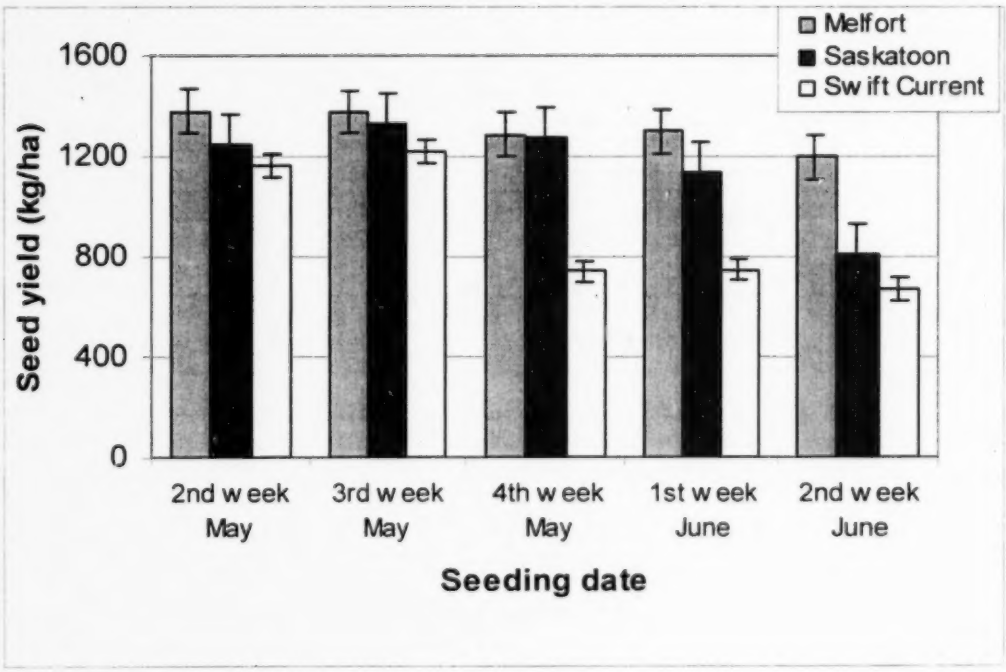

Figure 1. Effect of seeding date and location on the seed yield of lentil. The seed yield is averaged over 15 lentil varieties and two years (Melfort and Saskatoon) and one year (Swift Current).

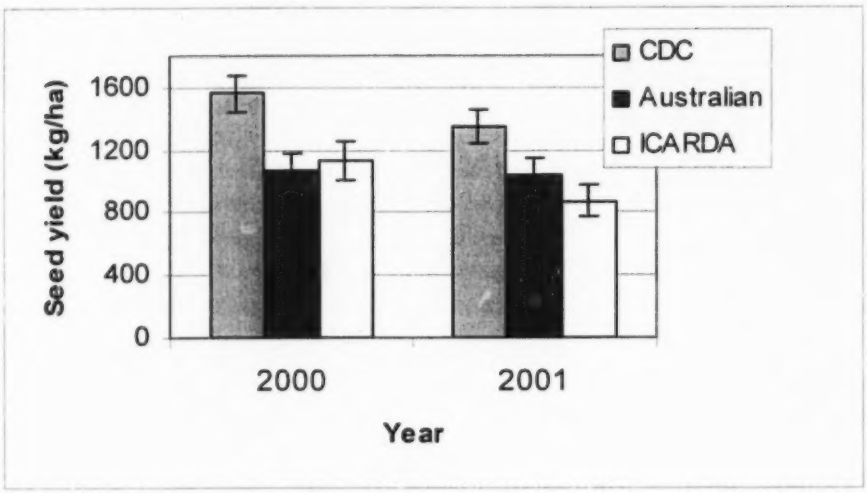

Figure 2. Performance of lentil varieties from the CDC breeding program, ICARDA and Australia in 2000 and 2001. Seed yield is averaged over three locations in 2000 and two locations in 2001

Discussion

The results of this study showed a large decrease in seed yield when seeding was delayed beyond the third week of May at Swift Current, the driest environment. Seed yield was maintained up to the first week of June in the moist Dark Brown soil zone at Saskatoon and up to the second week of June in the moist Black soil zone at Melfort. These results suggest that in dry environments typical of the southwestern part of the province, early maturity lentil varieties should be seeded before the third week of May to maximize performance. In moist environments typical of the northeastern part of the province, early maturing lentil varieties may be seeded late with no major penalty in seed yield. A long term study on adaptation of pulse crops in Saskatchewan (Johnston et al. 2002) reported that the lentil crop performed best at Swift Current, Scott, Outlook and Melfort based on yield and net returns and that seedling density and yield variability were lowest at Melfort. The results of the present study, as well as the above study (Johnston et al. 2002) support the current effort to extend the area of lentil production to the thin Black soil zone. Development of lentil cultivars that are earlier maturing with improved disease resistance will be beneficial. Studies investigating disease management for early maturing lentil varieties in the moist Black soil zone are currently under way. These studies are of critical importance because the success of lentil production in the northeastern part of the province will depend on an effective disease management program.

Germplasm from ICARDA and Australia performed poorly in comparison to local varieties implying poor adaptability of the exotic germplasm. These results suggest that direct introductions of early maturing lines is unlikely to be successful under Saskatchewan conditions, but that breeding to combine early maturity with high yield of local varieties will be worthwhile.

Study 3: Effect Of Seeding Date And N Fertilizer On The Yield Potential Of Early Maturing Lentil

Introduction

Lentil is considered a good N fixer but under dry soil conditions the crop may benefit from starter N (Saskatchewan Pulse production Manual, 2001). In moist environments starter N increases the vegetative growth and development of conditions ideal for disease development. The 'new' lentil cultivars developed at CDC tend to be less vegetative and earlier maturing than the traditional Laird-type lentil. The objective of this experiment was to determine the effect of three N fertilizer rates on phenology and yield of two lentil cultivars sown at three different dates in spring.

Materials and Methods

Two early maturing lentil lines (CDC Robin and CDC Redcap) were used in the study. Three levels of N fertilizer (15, 30 and 45 kg/ha N) and a control (0 kg/ha N) were applied to the lentil cultivars in a factorial design giving a total of eight treatments. These eight treatments were seeded at three seeding dates (1st week of May, 3rd week of May and 1st week of June) at Saskatoon and Melfort in 2001 and 2002.

Plot size and cultural management was as in study 2. In 2002, the experiment at Melfort was lost due to extremely dry conditions in early spring. Combined analysis of the data from the two locations in 2001 and one location in 2002 showed a significant interaction between location and seed seeding date for number of days to maturity and seed yield. The data from each location were therefore analyzed separately.

Results

At Saskatoon in 2001, seeding date had a significant effect on number of days to maturity with number of days to maturity decreasing with delay in seeding and seed yield increasing with delay in seeding (Table 1). The interaction between seeding date and N fertilizer rate was significant. Table 2 shows that the interaction was due primarily to the fact that seed yield increased with N fertilizer application when seeding was done at the 3rd week of May and that the response to N fertilizer application was not clear for the other two seeding dates. In 2002, seeding date had a significant effect on days to flowering, days to maturity and seed yield. Number of days to flowering decreased with day in seeding but the number of days to maturity was greatest for the June seeding date and least for the end of May seeding date. Seed yield was greatest for the June seeding date. Nitrogen fertilizer rate had a significant effect on number of days to maturity with higher N rates delaying maturity of lentil (Table 9). The interaction between N rate and seeding date was significant for the number of days to maturity and seed yield (Tables 9 and 10). Table 9 shows that higher rates of N fertilizer delayed maturity by six days for the June seeding date as opposed to 3 days for the May seeding dates. Nitrogen fertilizer application reduced seed yield for the June seeding date but had no significant effect on seed yield for the May seeding dates.

Table 8. Effect of seeding date on number of days to maturity and seed yield of lentil at Saskatoon in 2001 and 2002

Seeding date	Days to flowering	Days to maturity		Seed yield kgha^{-1}	
	2002	2001	2002	2001	2002
1st week of May	43a	90a	92a	1143b	1415b
3rd week of May	43a	84b	83b	1510a	1330b
1st week of June	40b	76c	93a	1642a	1828a
S.E.	0.3	0.5	0.7	78.6	122.7

Table 9. Effect of seeding date and N fertilizer on number of days to maturity at Saskatoon in 2002.

	Seeding date			Mean
N fertilizer rate Kgha^{-1} N	1st week of May	3rd week of May	1st week of June	
	Number of days to maturity			
0	90	81	89	87c
15	91	84	94	89b
30	92	84	94	90ab
45	93	84	95	91a
S.E.				0.4

Table 10. Effect of N fertilizer and seeding date on seed yield of lentil at Saskatoon in 2001 and 2002

N fertilizer rate	Seeding Date						Mean	
$Kgha^{-1}$ N	1st week of May		3rd week of May		1st week of June			
	2001	2002	2001	2002	2001	2002	2001	2002
0	1197	1502	1361	1304	1787	1949	1449a	1585a
15	1014	1388	1528	1417	1569	1793	1370a	1532a
30	1201	1348	1563	1431	1710	1800	1491a	1527a
45	1158	1421	1588	1167	1502	1770	1416a	1453a
S.E.							45.1	138.3

At Melfort, seeding date had a significant effect on number of days to flowering, number of days to maturity and seed yield (Table 11). The number of days to flowering and maturity decreased with delay in seeding. Seed yield was highest when seeding was done in the 3rd week of May. N fertilizer had no effect on seed yield or on phenological development.

Table 11. Effect of seeding date on number of days to maturity and seed yield of lentil at Melfort in 2001

Seeding date	Days to Flower	Days to Maturity	Seeding yield ($kgha^{-1}$)
Ist week of May	54a	100a	792b
3rd week of May	51a	95b	1102a
1st week of June	44b	93c	779b
S.E.	0.5	0.9	100.4

Discussion

In both 2001 and 2002, precipitation for the months of May and June was below average (Appendix 1) and this may have influenced the performance of the lentil crop. The very wet conditions in August delayed maturity of the June-seeded crop in 2002 but favoured seed yield. Application of N fertilizer had a positive effect on seed yield in only one

seeding date (3rd week of May at Saskatoon in 2001). On the other hand, N fertilizer delayed maturity significantly at Saskatoon in 2002 and this was not surprising because of the extremely wet conditions in August. These results are supported by previous research conducted at Swift Current where no difference in yield was observed between treatments that received starter N and unfertilized plots (Walley 2001).

Based on the results of this experiment and earlier reports, starter N application in lentil may delay maturity through extended vegetative growth. In seasons with late summer rainfall as in 2002, extended vegetative growth may occur at the expense of seed yield.

Study 4: Weed Control Options For Late Seeded Lentil

Introduction

Lentil, like other pulse crops, is a poor competitor against weeds. Weed control is therefore a challenging problem to lentil producers in Saskatchewan. This experiment explored weed control options for potential use in a cropping system that uses early maturing lentil seeded late in spring. The hypothesis was that delayed seeding may give growers a chance to use a pre-seeding burnoff with Roundup (Glyphosate), reducing the use of post-emergence herbicides.

Materials and Methods

The experiment was designed in collaboration with the Weed Control Team, Crop Development Centre. Two lentil cultivars, CDC Milestone and CDC Redcap were used in the study conducted at three locations (Saskatoon, Melfort and Scott) in Saskatchewan. The cultivars were sown at three seeding dates (1st week of May, 3rd week of May and 1st week of June). In 2001, the weed control treatments imposed on each cultivar at each seeding date were as follows:

1. Burnoff (Roundup) with no post-emergence herbicide
2. Burnoff (Roundup) + post-emergence herbicides (Sencor and grass herbicide)
3. Trifluralin +Sencor (split) +grass herbicides
4. Weed-free control at Melfort and Scott or weedy control at Saskatoon

In 2002, the protocol was modified as follows:

1. Burnoff only (untreated check)
2. Weed free check (pre-seeding burn-off+post-emergence broadleaf and grass weed control+ hand weeding)
3. Pre-seeding burnoff+post-emergence grass weeds control
4. Pre-seeding burnoff +post-emergence broadleaf and grass weeds control
5. Pre-seeding burnoff+ 2/3 post-emergence broadleaf and grass weeds control

The herbicides were applied at recommended rates at recommended growth stages of the lentil plants. In 2002, Poast was used for controlling grassy weeds and Sencor for controlling broadleaf weeds. Roundup was incorporated during the last week of April with a second incorporation made before seeding for plots not getting post-emergence weed control.

Experiments were seeded on land that was fallow the previous summer. The treatments were arranged in a split-plot design with seeding date as the main plot, weed control the subplot and lentil cultivar the sub-subplot. Plot size was 2.25m x 6 m at Saskatoon and Scott and 1.75m x 4.56 m at Melfort. No nitrogen fertilizer was applied to the crop. Rhizobium inoculant was applied at seeding at all locations at the recommended rate. Data were analyzed using the GLM procedure of SAS.

Results

Due to drought at Melfort and drought followed by grasshopper infestation at Saskatoon, the 2002 results from the two locations were not available. Results of the experiment conducted at Scott in 2002 are reported below, but lentil yields were low due to drought. Treatment effects may have been confounded by drought stress hence the results need to be interpreted with caution. The results from 2001 are summarized below. With only one season data available, it is important that these results be regarded as preliminary.

The effects of herbicide treatments on the two lentil cultivars were similar hence the results are averaged over cultivar.

In 2001, weed pressure was very low at Melfort due to low precipitation (Appendix 1). The results showed a significant effect of weed control treatment on seed yield of lentil at the first seeding date only (Table 12) with the Roundup burnoff treatment yielded significantly lower than the Roundup/Sencor/Poast treatment or the Trifluralin/Sencor/Poast treatment. At the second seeding date, the lentil yield from the weed free treatment was slightly higher than lentil yield from the plots with post-emergence herbicide treatments but the difference was not significant. The seed yield of lentil was the same for the three weed control treatments when lentil was seeded in June.

At Saskatoon, weed pressure was high, more so during the first seeding date. This was reflected in low lentil yield due to competition from weeds (Table 13). Among the weed control treatments, the Trifluralin/Sencor/Poast treatment gave the best lentil seed yield for all seeding dates. The Roundup burnoff or Roundup/Sencor/Poast treatments did not give adequate weed control especially at the first two seeding dates when the weed pressure was high. This resulted in reduced seed yield of lentil compared to the Trifluralin/Sencor/Poast treatment. Weed pressure was generally low when seeding was done in June and the seed yield of lentil was higher under low weed pressure. Visual scoring for level of control of wild oats and wild mustard showed no effect of pre-seeding Roundup applied alone for the first and second seeding dates (Table 14). Level of control for the two weed species was much higher for the June seeding date . The other two treatment gave adequate control of the two weed species except wild mustard in the

second seeding date in the Trifluralin/Sencor/Poast treatment.Weed species other than wild oats or wild mustard were present in Saskatoon, these and other environmental factors may account for very low lentil yields.

At Scott lentil yield in the Roundup burnoff treatment was significantly lower than in the other two treatments or the weed free control (Table 15). The Trifluralin/Sencor/Poast treatment resulted in higher lentil yield than the Roundup/Sencor/Poast treatment when lentil was seeded during the 1st week of May but the trends were reversed when lentil was seeded 3rd week of May. Seed yield of lentil was the same for the three chemical weed control treatments and the weeded control when seeding was done during the 1st week of June. Visual scores for level of control of wild oats and wild mustard showed no effect of pre-seeding Roundup applied alone for the first and second seeding date (Table 16). Roundup alone provided about 50% weed control when seeding was done in June. The other two treatments provided adequate control of the two weed species. The low seed yield for lentil was, therefore, not due to weed pressure but likely to interaction between seeding date and other environmental factors.

In 2002 at Scott, lentil seed yield was low due to drought stress (Table 17). The mean effect of weed control treatment on lentil seed yield was not significant though differences among treatments were greater when lentil was seeded during the 1st week of May or the 3rd week of May and much smaller when lentil was seeded in June (Table 17). Visual weed control was assessed for a number of weed species including wild oats, lamb's quarters, redroot pigweed, prostrate knotweed and shepherd's purse. Results for wild oats and lamb's quarters control are given on Table 18. Roundup burnoff alone or Roundup burnoff with post-emergence Poast gave the poorest control of both weed species. The best control for both species was obtained when pre-seeding burnoff was followed with post-emergence Poast and Sencor. Reducing Sencor application to two-thirds of recommended rate lowered the level of control for both weed species.

The trends were the same for the control of weed species other than wild oats and wild mustard hence data for other weed species are not presented in this report.

Table 12. Effect of weed control treatment and seeding date on seed yield of lentil at Melfort

Treatment	Seeding date			Mean
	1st week May	3rd week May	1st week June	
	Seed yield kgha^{-1}			
Roundup Burnoff	1208	1527	1138	1291a
Roundup+Sencor +Poast	1618	1570	1158	1449a
Roundup+Sencor+Poast	1700	1689	1166	1518a
Weed free control		1713		
S.E (Seeding date)				68.1
S.E. (Treatment)				74.6

Table 13. Effect of weed control treatment and seeding date on seed yield of lentil at Saskatoon

Treatment	Seeding date			Mean
	1st week May	3rd week May	1st week June	
	Seed yield (kgha^{-1})			
Roundup Burnoff	41	89	313	148a
Roundup+Sencor +Poast	79	108	476	221b
Trifluralin+Sencor+poast	196	411	844	484c
Unweeded control		57		
S.E. (Seeding date)				26.8
S.E. (Treatment)				24.9

Table 14: Effect of planting date and weed control treatment on the control of wild oats and wild mustard in Saskatoon in 2001

Treatment	Seeding date						Mean	
	1st week May		3rd week May		1st week June			
	Wild oats	Wild mustard	Wild oats	Wild mustard	Wild oats	Wild mustard	Wild oats	Wild mustard
	% Weed control							
Roundup Burnoff	0	0	0	0	66	91	22b	30c
Roundup/Sencor /Poast	97	100	77	98	99	95	91a	98a
Trifluralin/Sencor/Poast	98	97	97	47	100	89	98a	78b
Unweeded control			0	0				
S.E. (Seeding date)							1.1	1.4
S.E. (Treatment)							0.7	0.8

Table 15: Effect of weed control treatment and seeding date on seed yield of lentil at Scott Research Farm in 2001

Treatment	Seeding date			Mean
	1st week May	3rd week May	1st week June	
	Seed yield ($kgha^{-1}$)			
Roundup Burnoff	292	490	597	459a
Roundup+Sencor +Poast	1488	1933	432	1284b
Trifluralin+Sencor+Poast	1957	1395	478	12771b
Weeded control	1515	1922	422	1286b
S.E. (Seeding date)				57.8
S.E. (Treatment)				69.2

Table 16: Effect of seeding date and weed control treatment on control of wild oats and wild mustard at Scott Research Farm in 2001

Treatment	Seeding date						Mean	
	1st week May		3rd week May		1st week June			
	Wild oats	Wild mustard	Wild oats	Wild mustard	Wild oats	Wild mustard	Wild oats	Wild mustard
	% Weed control							
Roundup Burnoff	0	0	0	0	60	43	20c	14b
Roundup/Sencor /Poast	97	80	93	91	95	98	95ab	90a
Trifluralin/Sencor/Poast	99	96	70	80	93	80	87b	85a
Weed free control	98	97	98	96	96	97	97a	97a
S.E. (Seeding date)							1.7	3.3
S.E. (Treatment)							1.7	2.9

Table 17: Effect of weed control treatment and seeding date on seed yield of lentil at Scott Research Farm in 2002

Treatment	Seeding date			Mean
	1st week	3rd week May	1st week June	
	Seed yield ($kgha^{-1}$)			
Roundup Burnoff	185	285	173	214a
Roundup+Sencor +Poast+handweed	255	262	100	206a
Burnoff +Poast	240	323	165	243a
Burnoff+Poast+Sencor	257	373	120	250a
Burnoff+Poast+2/3 Sencor	200	402	152	251a
S.E. (Seeding date)				36.9
S.E. (Treatment)				17.1

Table 18: Effect of seeding date and weed control treatment on control of wild oats and lamb's quarters at Scot Research Farm in 2002

Treatment	Seeding date						Mean	
	1st week May		3rd week May		1st week June			
	Wild oats	Lamb's Quarters	Wild oats	Lamb's Quarters	Wild oats	Lamb's Quarters	Wild oats	Lamb's Quarter
	% Weed control							
Burnoff only	0	0	13	10	53	20	22	10
Roundup+Poast+Sencor+handweed	100	100	99	100	100	100	100	100
Burnoff+ Poast	0	0	13	18	50	5	21	8
Burnoff+Poast+Sencor	30	33	65	100	60	88	52	73
Burnoff+Poast+2/3 Sencor	20	30	28	23	33	75	27	43
S.E. (Seeding date)							6.3	5.9
S.E. (Treatment)							7.3	5.0

Discussion

The first year results of this experiment showed that under high weed pressure, pre-seeding Roundup burnoff alone will not provide adequate weed control in lentil seeded in May. Although pre-seeding Roundup burnoff provided some level of weed control in lentil seeded in June, the level of control was still not adequate. Under high weed pressure the use of Trifluralin followed by post-emergence Sencor and Poast was superior to pre-seeding Roundup burnoff followed by Sencor and Poast at Saskatoon but the two treatments were equal at Scott. In 2002 at Scott, results were inconclusive due to severe drought early in the growing season, but the indications were that pre-seeding Roundup burnoff or pre-seeding Roundup burnoff followed by Poast will not provide adequate weed control in lentil and that pre-seeding Roundup burnoff followed by Poast and a full rate of Sencor will give best weed control. The relationship between lentil seed yield and weed control treatment was very poor likely due to the confounding effects of drought stress.

With only a single season of good data these findings will need to be confirmed before firm conclusions can be drawn.

CONCLUSIONS

- Emergence in fall-seeded plots was influenced by seeding date, lentil variety and by use of a dormancy enhancer.
- The final plant density and the seed yield of lentil in fall-seeded plots were approximately 50% of that in spring-seeded plots. Fall seeding cannot be recommended at this time.
- Emergence in fall-seeded plots was not consistent from year to year or location to location. This confirms that the performance of fall seeded lentil is very variable and dependent on weather conditions at the time of seeding.
- The results of the spring seeding date study showed a large decrease in seed yield when seeding of early maturing high yielding varieties was delayed beyond the third week of May at Swift Current, the driest environment. Seed yield was maintained up to the first week of June in the moist Dark Brown soil zone at Saskatoon and up to the second week of June in the moist Black soil zone at Melfort. Lentil growers can use this information as a window of opportunity to respond to market conditions for red lentil just when the Turkish crop is harvested and the Australian crop is planted.
- The N fertilizer experiment showed no difference in yield between the plots that received starter N and unfertilized plots but a delay in maturity of lentil in plots that received high levels of starter N.
- Single season results from the weed control experiment showed that Roundup burnoff alone will not give adequate weed control for lentil seeded late in spring. Under high weed pressure the use of Trifluralin followed by post-emergence Sencor and Poast gave superior or equal results compared to pre-seeding Roundup burnoff followed by Sencor and Poast.

Papers and presentations

- Results of the spring seeding date experiment were presented Pulse Crops Research Workshop, November 2000, Winnipeg, Manitoba
- Results of the spring seeding date experiment were presented (in poster format) at the North American Pulse Improvement Association meeting in Fargo, North Dakota, October 30-November 2, 2001.
- A summary of the results was also published in the Melfort Newsletter.
- A manuscript (in form of a short communications) will be prepared to communicate results of the lentil fall seeding experiment
- A full manuscript is under preparation for publishing the spring seeding date experiment.

Areas for Further Development

- Results of the spring seeding date experiment have been presented at various grower meetings in the province. Growers in northeastern Saskatchewan will need a reliable disease management strategy before lentil becomes a choice crop for production.

- The chemical weed control experiment was inconclusive due to extremely dry conditions in 2002. The protocol developed for this experiment and modified in 2002, will need to be tested for two more years before firm conclusions can be drawn from the study.

Information of Benefit to Producers, Processors or Governments

- Fall seeding of lentil is not a realistic option for Saskatchewan. This is a sharp contrast with the Palouse area of the USA, where winter lentil production results in higher yield levels.
- Late spring seeding of red lentil would appear to be a viable crop option for Black Soil zone areas of Saskatchewan.
- Locally adapted lentil varieties appear to offer the highest yield potential regardless of seeding date in comparison to lentil germplasm from the Middle East or Australia.
- A detailed economic analysis of the yield and price levels and market signals that provide the best market opportunities for late season sowing of red lentil in the Black Soil areas could be a useful counterpart to future applied research.
- Black Soil zone production of red lentil may help provide supply and demand stability for red lentil export markets and for domestic splitters.
- Agri-Arm sites at Redvers, Canora, Indian Head and Melfort may be interested in developing producer demonstrations and specific agronomic production packages for red lentil production.
- New red lentil varieties that show improved yield potential, disease resistance and, within a few years, an expanded range of herbicide tolerance should be used in future research and demonstrations concerning red lentil production.

REFERENCES

Johnson, EN, Kirkland, K.J. and Gusta, L.V. 1998. Late fall and early spring seeding of herbicide tolerant canola. Soils and Crops '98. Extension Division, University of Saskatchewan.

Johnston, A.M. 2002. Regional adaptation of pulse species in Saskatchewan. Final Report of AFIF Project, June 2002.

Kusmenoglu, I and Aydin, A. 1995. The current status of lentil germplasm exploitation for adaptation to winter sowing in the Anatolian Highlands. In " Autumn Sowing of Lentil in the Highlands of West Asia and North Africa" . Proceedings of a conference held at Antalya, Turkey Dec 12-13, 1994.

Walley, F. L., Johnston, A.M., Lafond, G. and Gan, Y. 2001. Optimizing fertility in lentils and peas. Pulse Days 2001. Saskatchewan Pulse Growers.

Appendix 1. Precipitation in the summer months of 2000, 2001 and 2002 at Melfort, Saskatoon, and Swift Current

Location/Year	May	June	July	August	Total
			Precipitation (mm)		
Melfort					
2000	42.6	73.6	106.4	46.8	269.4
2001	9.0	23.4	46.4	11.4	90.2
2002	5.0	56.2	58.4	130.0	249.6
Saskatoon					
2000	17.2	54.2	83.2	45.2	199.8
2001	26.4	26.6	53.6	11.4	118.0
2002	1.5	56.6	69.0	72.5	199.5
Swift Current					
2000	64.3	54.0	124.6	5.9	248.8
2001	22.4	31.8	63.0	3.2	120.4
2002	17.8	130.9	63.0	118.7	326.6
Scott					
2001	36.0	49.0	40.0	3.0	128.0
2002	4.1	64.1	27.0	39.1	134.3
Normal					
Melfort	40.6	63.3	70.6	50.8	225.3
Saskatoon	45.3	62.8	59.6	38.5	206.2
Swift Current	44.4	69.4	48.5	38.7	201.0